2020

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by

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AN UNDERGRADUATE THESIS

Presented to the Faculty of

The Environmental Studies Program at the University of Nebraska-Lincoln

In Partial Fulfillment of Requirements

For the Degree of Bachelor of Science

Major: Environmental Studies

Minor: Energy Science

Under the Supervision of Dr. Taro Mieno

Lincoln, Nebraska

May, 2020

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University of Nebraska, 2020

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Abstract:

In this study, we strive to analyze the economic impacts on the firms participating in an emission trading system. Many studies have analyzed the impact on emission control and whether or not it is an effective tool in reducing greenhouse gas emissions. This was achieved by running a log regression of sales against emissions from before and after the introduction of the carbon market. The statistical technique of Difference in Differences (DID) was used to observe the outcome against a control group, or those that had not participated in said market. The Korea Emission Trading Scheme (KETS) was the focus of this study as it is relatively new and not many studies of this sort have been conducted for the region. Unfortunately, the KETS has seen it's share of issues in the rollout of this policy which in turn has resulted in a strain on those firms participating in the market. Shortage of permits, Emission cap disputes, and international opinion concerns have led to a reduction of 20 percent in production and an 18 percent reduction in efficiency as compared to where these firms would have been had they not entered the carbon market.

Introduction:

As it is well known across the globe, the outlook on climate change and its impacts on a nations' ability to thrive is anything but optimistic. Instability in the ecosystem can have a demonstrous effect on how we currently operate on a day to day basis and this change in the status quo of how we operate will inevitably put pressure on the state of world economies. There are many methods of tackling this issue being implemented today. When it comes to unwanted carbon dioxide entering the atmosphere, carbon pricing is a policy that is being tested as a method of throttling the release of the gas to manageable amounts. Carbon pricing can be an aggressive tool for ensuring that private industry is not polluting unregulated. It takes an environmental issue, attaches a value to it, and enters it into a market that will hopefully one day become self sustaining. However, not many studies have been conducted on the effectiveness of these markets and the impacts they have on the economies they are incorporated into. In this project, the carbon market in South Korea will be the main focus, as it is large and well established, which will give a good look at the impact it has had on the region. This was completed through a statistical analysis of revenue vs efficiency, before and after the implementation of the carbon market, for both firms who participated in the emission trading scheme and those that did not. After running the statistical analysis it was found that those who had to reduce emissions because of the carbon market implementation experienced 20% reduction in their sales on average. This is expected as those who participated in the market are given emission caps, and the only way of cutting these emissions is to cut production/sales. Another analysis that was conducted was a look at production efficiency of participating firms, however, it was found to be not statistically significant.

Background/Literature Review:

Progress is what drives change, and innovation drives that progress. It is already very clear to scientists around the globe that our current framework for living is not sustainable. 97 percent of climate scientists are in consensus that there is a major threat to our ecosystem and action needs to be taken. Overpopulation, pollution, water scarcity, natural disasters, overfishing, deforestation are all issues that must be reevaluated with sustainability in mind. However only 49 percent of the general population share this belief, and even less, only 29 percent of CEOs are actively addressing climate change. The shortcoming for the general population is simply all of the misinformation available at the click of a button. On the other hand, the major lapse in understanding between scientists and CEOs needs to be addressed.

This is simply due to a lack of a universal language in which both parties can use to communicate. Ecologists will continue to care about the Earth and corporations will continue to care about profit. Society can't blame them for thriving in a free market. However, there must be a common ground in which on can reach to get them to understand the impacts of frivolous resource extraction and endless pollution dumping into the atmosphere (Mills, 2015)

The quickest way to understanding is by putting it in the terms of economics. Maybe if an actual dollar value is added to the things that are being destroyed, producers might be more inclined to be more responsible with those resources. According to a study done by economist Robert Costanza in 1990; Globally, ecosystems and the services they provide equal roughly $33 trillion. Adjust that for inflation and it comes out to approximately $62 trillion, and these are just the positives (Martin, 2014). Imagine if the time was invested into calculating the future costs of dumping tons of carbon dioxide into the atmosphere. Maybe then our market would see real change from corporations, governments, and those with the power to make those changes.

There is no guarantee that these figures will sway company decisions in any way. However, without communication, there can be no progress and creating common ground creates an avenue in which this communication can occur. In 2009 a major step in the right direction was made when the US government created a formal measure of the value of reducing carbon pollution. This is being referred to as the social cost of carbon. According to the 'Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis' of 2016, by 2020 the social cost of carbon emitted into the atmosphere is projected to reach $42 per ton. At 9 billion tons of carbon emissions in 2014, that equals approximately $378 billion per year, and that number will only continue to rise (Gómez-Baggethun, 2011).

While some believe the monetization of ecological assets will provide an avenue to conversation on the value of our environment as a whole, there are also numerous economic advantages to such action. Many economic policies are easier to implement when all aspects of the policy are able to be analyzed fiscally. A carbon tax in particular is a policy that is currently being played with in different sectors across the world. There are still some issues with the policy as it is new and there is quite a bit of evaluation that needs to be done (Stram, 2014). Also, there is quite a bit of push back from the general public, as is expected with any tax. While a carbon tax across the board can be seen as the most beneficial policy, it may be more feasible to target producers more heavily than consumers as the producers are the primary contributors to carbon emissions in the world. However, tax exemption policies in place currently are making these taxes ineffective and are even having negative impacts on the economy in these areas (Goulder, 2013). Carbon tax is just one form of carbon pricing that is simply the idea of adding a price tag to emitting carbon into the atmosphere. Carbon pricing and in particular, carbon taxing is also one of the most effective ways in incentivizing innovation in green technologies (Fischer,

2003). It gives these companies the incentive to invest in these technologies that will decrease their carbon output as long as those technologies are cheaper than the tax. As soon as the tax becomes cheaper than innovating, these industries are, of course, going to be willing to pay that tax. While the tax revenue will certainly be beneficial to our economy, the goal is to lower emissions in order to reduce the effects of global warming. Therefore, there must be a steady balance between innovation costs as well as the tax level. Too high of tax and there will be major pushback from these industries and no politician will endorse a policy that has no support from industry. Too low of tax and emissions will not drop as expected, rendering the policy ineffective. Carbon tax is a very difficult thing to accomplish effectively as there are many unknowns. Marginal costs and benefits for each individual firm needs to be known to provide an accurate tax, but these numbers are held close to the chest as they are aware of the fact that giving this information away will inevitably lead to some sort of government intervention.

There are also other incentives to carbon pricing. Companies that take a heavy beating from taxes due to high emissions are likely to steer away potential investors, while the "greener" companies that see little negative impact from said policies, are going to appear much more lucrative to those on wall street.

There are numerous questions to address when approaching this topic. Due to the many externalities that are inevitably involved with economic policy, especially when dealing with the environment, one will need to decide what the scope is going to be. Will it be focusing on just one sector of industry and how carbon pricing affects the welfare of that industry? Or, one could possibly look at a certain region and see how carbon pricing has had an effect in that area. Another thing that could be looked at is the possible different types of carbon pricing and how each policy might have a more beneficial impact on both the economy and environment.

Between carbon taxing, results-based climate finance, and cap and trade systems, which policies are most effective and why? Here, an emission trading scheme is going to be analyzed. The Emission Trading Scheme (ETS) is a market-based greenhouse gas (GHG) reduction regulatory system, as defined by Article 17 of the Kyoto Protocol. The ETS allocates the tradable emission permits to companies, which is subject to the allocation of emission permits based on GHG emissions standards, and allows them to trade any excess or shortage of permits with other companies.

There are a few carbon markets that have been well established in recent years, one of these being the EU Emission Trading Scheme. This scheme, like all, works on a cap and trade program. It is also the world's largest and world's first trading scheme of its kind being established in 2005. With the EU leading the globe in ambitious emission reduction goals, ambition policies were needed in order to achieve said goals, and it has been working. As of 2020, emissions are 21 percent lower than that in 2005 when established (Ellerman, 2010).

Another nation, the Republic of Korea launched its emission trading system in January of 2015 and is already the second largest behind the EU trading scheme. It currently covers 525 businesses from 23 sectors that accounts for approximately two-thirds of the country's total emissions (Paltsev, 2008). At the start of this program, the country set a target of reducing emissions 30 percent by the year 2020 through the use of permit trading. In order to understand the current progress of the Republic of Korea's emission trading system, one must analyze what effect the permit trading system has had on the country's economy as well as the current effects it has had on emission reduction. This will be a market analysis after the implementation as well as an ecological impact assessment on whether or not there has been a reduction in emissions.

There have been a few studies done on the Republic of Korea's current emission trading system, however, was unable to identify any analysis done as of late. As far as economic development goes, a lot can happen in two years so that analysis will do its best to truly find the most up to date information in fortifying current research and updating data to reflect the current state of the country's economic and environmental situation. Hopefully, as world economies start to roll out these policies and are able to closely monitor the effects of different taxes and trading systems for carbon, they will be able to identify the most effective method of both reducing emissions as well as maintaining healthy economies.

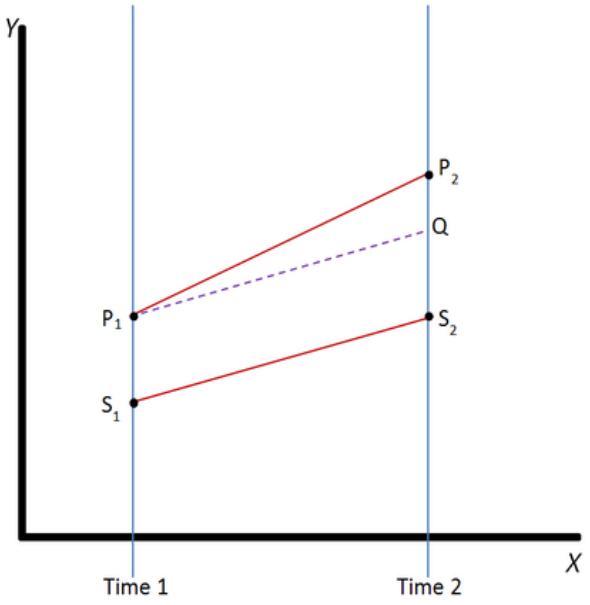
One of the most recent analyses of the Republic of Korea's current policy implementation is the 2018 report "The Korea Emissions Trading Scheme: Challenges and Emerging Opportunities" assembled by the Asian Development Bank. This report took a step back and covered everything from looking at greenhouse previous greenhouse emissions, to the emissions trading scheme timeline, to an assessment of the first phase of the actual trading scheme. This report is a purely economic analysis of the trading scheme, so the goal of this project is to bring the economic analysis together with the effectiveness of emission reduction in the country.

Methods:

Analyzing the effectiveness of a carbon market can be relatively subjective, depending on where your priorities lie. One may work for the energy production industry and would most likely view a carbon tax/trading scheme as a hindrance to maximum profit. However, if you work in the business of protecting the earth and reducing carbon dioxide output, you will most likely view any reduction of pollution as a win. This study will be analyzing the consumer side

of the market. It will be using R Software to analyze statistical data on whether private firms are more productive (Revenue/Energy Use) before or after the carbon market was introduced. This can show that while energy production companies may see a reduction in profit, the savings may be transferred to the individual consumers and firms that are consuming that energy.

The data being used in this study has been confidentially collected from a select group of firms in South Korea where data was available both before and after the carbon market was introduced. An analysis of revenue against energy use can be a signal as to what the effects of a carbon market are on the economic well being of the region as a whole. The main statistical analysis being used in this paper is known as Difference in Differences of DID. This method essentially takes data from a treatment group and a control group. Specifically, data from before the treatment (P1 and S1) and then data after the treatment (P2 and S2). The data from the control group after the treatment is then used to create a parallel of the data of where the treatment group would have been had the treatment not been applied (Dotted line Q). This parameter is then compared to the actual data from after the treatment and the difference in those two is considered the treatment effect (Difference between Q and P2). See image.



This analysis will be looking at data from multiple firms within South Korea. When the Korean Emission Trading Scheme was introduced, not all firms were forced to participate. Many of the large contributors decided to opt in while the smaller firms did not. Therefore, the large firms will be our treatment group, the treatment being the introduction of KETS, and the smaller firms will be the control group who decided to opt out of the system. Thus, comparing the revenue vs. energy use data from before and after for both large and small firms will give us the difference in differences data to analyze the impact of the carbon market on efficiency within this market.

A log regression analysis will be run through R software, creating a model in which the data from individual firms will be plugged into. One model will be run to find production level change after the implementation of the carbon market for participating firms. The other model will find production efficiency, or production per carbon emission after the carbon market initiation. The following equation will be used:

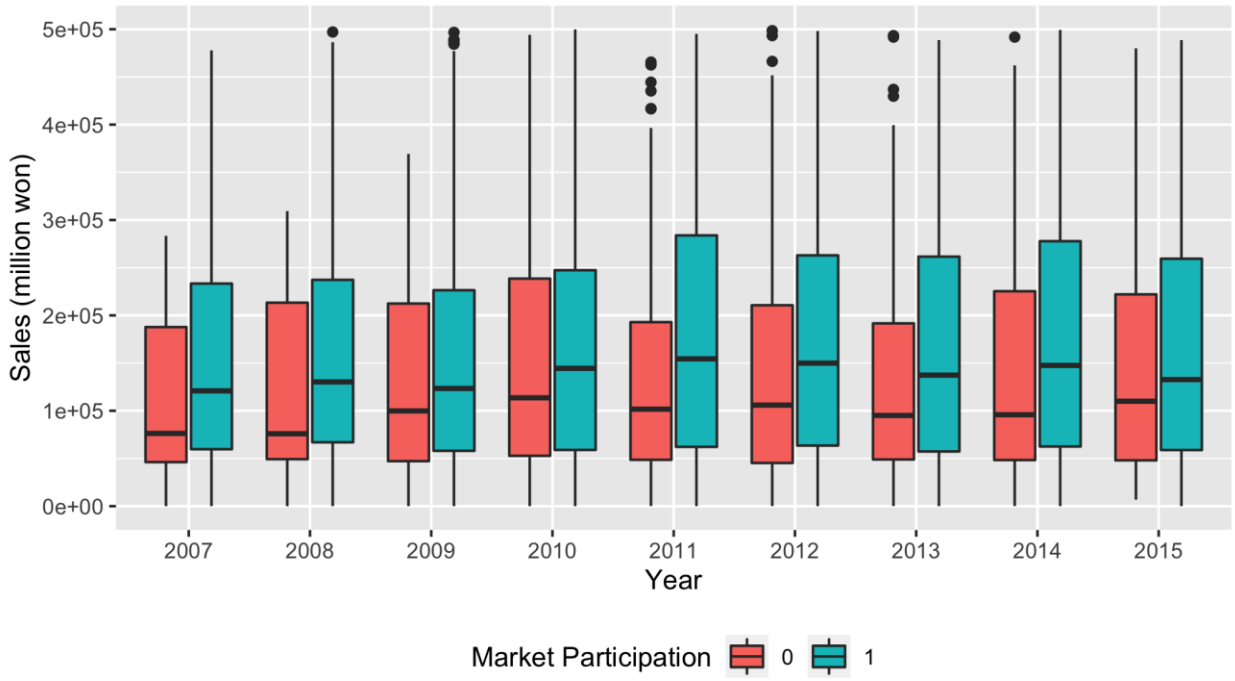
$$y = b_0 + b_1 D_{i,t} + \eta_t + v_{i,t}$$

Here, *y* will be the dependent variable, which will either be *sales* for the first model or *sales/emissions* for the second. Next, b_0 will be the level of *y* had the firm not participated in the market. Following, $b_1$will be the difference in the level of the dependent variable between those who participated and those that did not. $D_{i,t}$is a metric of participation, resulting in a 1 if they did participate in the carbon market, and a 0 if they did not. Therein lies the "Difference in Differences" aspect of the analysis. For example, say a firm did not participate. $D_{i,t}$ would become 0, cancelling out $b_1$leaving the dependent variable to equal b_0 plus the error term ($v_{i,t}$).

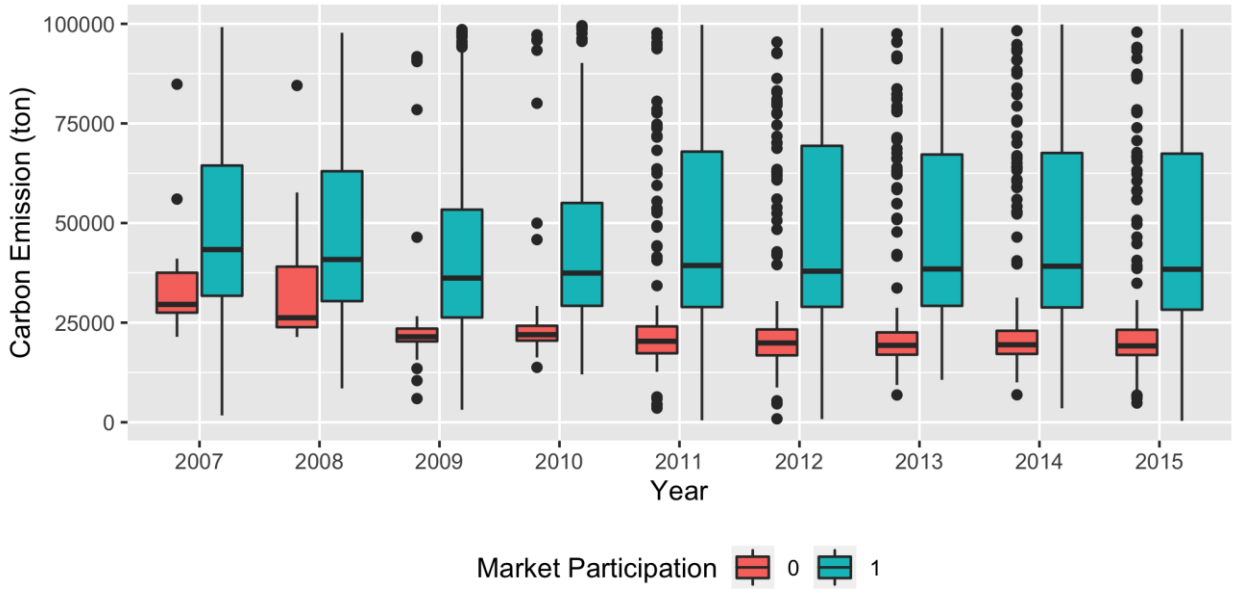
On the other hand, if the firm did participate, the dependent variable would become b_0 plus the difference in the level of y between the firms that did and did not participate. Finally the subscripts i and t denote the firm and the year in which the data was gathered.

Data:

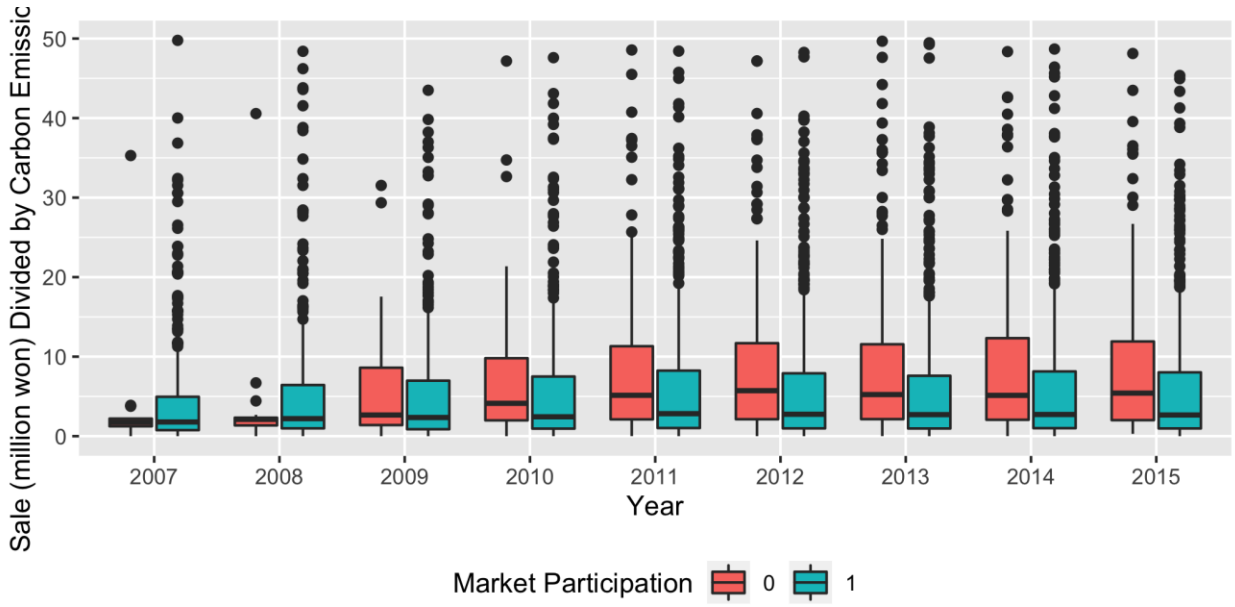
We estimate the model using annual sales and carbon emission data observed for 850 firms over 9 years from 2007 to 2015. Among the 850 firms, 595 firms participated in the Korean Carbon Permit Trading scheme in 2015. The following figure presents the boxplot of annual sales in million won for those who participated and did not participate in the trading scheme. As the plot portrays, the firms that participated in the market had a higher output in production across the board. This would indicate a trend of larger firms participating while smaller firms did not.



The figure below shows the boxplot of annual carbon dioxide emission (tons) for those who participated and did not participate in the trading scheme. As expected, there is a strong correlation between larger firms and a higher output of emissions as compared to the smaller firms.

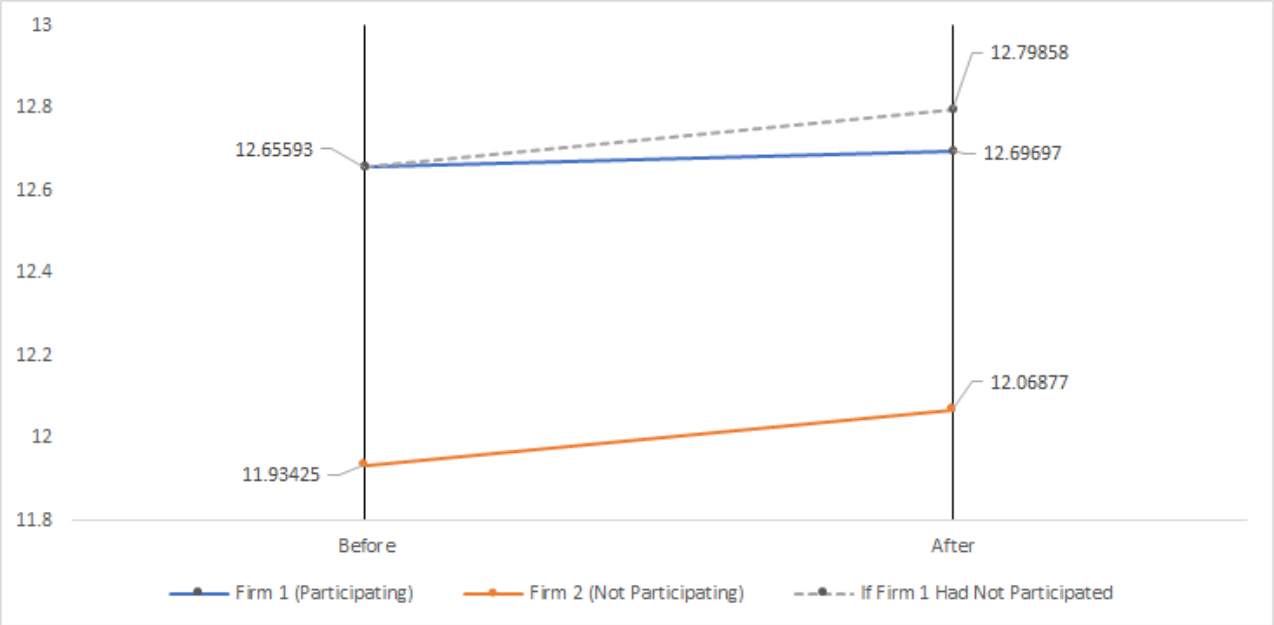


Finally, the figure below presents annual carbon use efficiency (sales divided by carbon emission). Here it is evident that efficiency in the terms of sales per emission is not a major focus of larger firms. Higher output in production is of course going to result in a higher output in emissions. The plot also indicates that the smaller firms (those not participating in the market) are much more efficient in these terms, indicating a negative logarithmic relationship between sales and emissions as the firm size increases.



Results:

As discussed, two models were run throughout this analysis with a sample size of approximately 850 firms, observed annually. The first regression ran looked at production changes for participating firms once entering the carbon market. It was discovered that firms outside of the carbon market saw an approximate increase of 0.13 points in sales. On the other hand firms participating in the market only saw an increase of 0.04 points. This indicates that the participating firms saw an approximate 20 percent decrease in sales from what they would have seen had they not entered the emission trading market. See graph for illustration:



The second regression, the main goal of the project, aimed at identifying change in efficiency after the introduction of the carbon market. It was identified that firms participating in emission trading experienced a decrease in efficiency by approxiamately 18 percent. However, these results identified a p-value outside of the parameters and rendered the results "not statistically significant.

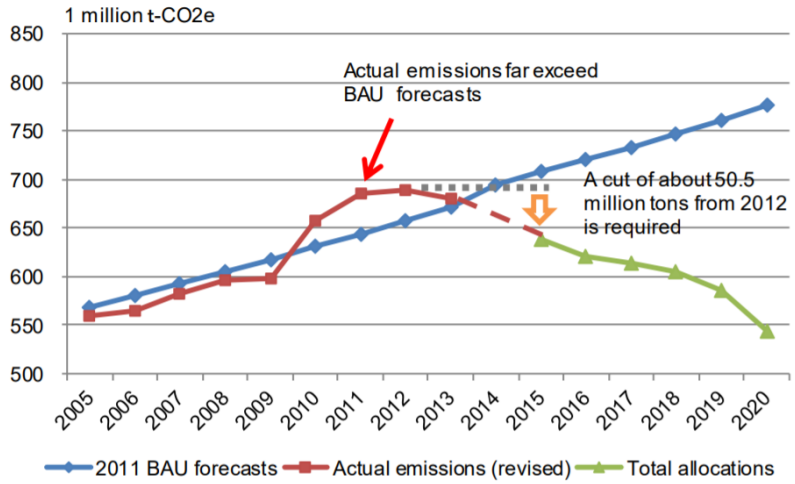
Discussion:

The results of the first regression analysis are something to be expected. When entering an emission trading scheme, firms are either going to be buying more permits to reduce their need to cut back production, or as with the case in Korea, a shortage of permits presents the need for almost all firms to cut back production in order to avoid fines. This expected cut back is illustrated by the data found by the analysis of almost 20 percent decrease in sales of where they should have been had they not entered the carbon market.

While not statistically significant, one would assume the decrease in productivity to be a valid representation as well. With the implementation of an emission trading scheme, decrease in production is expected. As stated before, with Korea's emissions actually increasing rather than decreasing as a result of the trading scheme, it is also expected that the efficiency (production/emissions) would decrease within the carbon market. There are also many other externalities that this study can not account for that may influence the outcome. As mentioned before, Korea has had some hurdles with getting their emission trading program up and running. Possibly learning from the initial failures of the EU emission trading scheme, which provided way too many permits and the cost dropped close to zero; the Korean emission trading scheme cut back on the number of permits it would supply to the firms. This created a large dispute in the industry. Throughout the first implementation period (2015-2017), the industry was provided 1,597 million tons in allocations which was about 400 million tons short of the requirement to reach the first period's emission reduction goal. This was likely just an ambitious push for reduction to get ahead of the curve for the first period but it inevitably led to very little activity in the market (Zhang, 2016). This only seemed to compound with the rise of production in Korea.

Another major contention that most likely led to skewed data was the dispute of the business as usual (BAU) emission projections. Initial BAU projections for 2020 were made in 2009, likely as a result of the Copenhagen Summit held that year. These projections showed a steady linear increase from where they were now. However, going into 2010, Korea hit an economic boom and saw a sharp increase in energy consumption fueled by equipment investment in energy intensive sectors. Following this, there were reconsiderations for the projections considered in 2011 and 2013. Unfortunately, they were both unsuccessful as it was

believed the publishing of these changes would shift confidence in the nation of Korea (Ha, S., Tae, S., & Kim, R., 2019).



A cornerstone to a successful emission trading scheme is an accurate projection of future BAU levels. That way, a realistic goal for cutting those emissions can be set. Due to Korea having underestimated their projections, they need to cut a much larger percentage of emissions in order to reach their reduction goal. These events are likely what led to a reduction in permit supply and resulted in the drop in efficiency.

Finally, as an unintended result of the implementation of a carbon market, these new policies are likely to push some firms to outsource production to areas where these restrictions don't exist. Ideally the only way to fight this would be to implement these policies everywhere. Restrictions are likely to vary by region but implementing carbon pricing everywhere would one, help abate carbon emissions, and two, discourage pushing production to other countries.

Conclusion:

A carbon market is a useful tool, when implemented correctly, in reducing carbon emissions as well as limiting strain on firms participating in said market. These markets are

designed to be self-sustaining, where the buying and selling of permits is to abide by basic market theory and require very little intervention. Again, this is if the initial implementation is done correctly which would include correct allocation of permits, a realistic emissions cap setting, and a logical permit price.

As is presented, the introduction of a carbon market is likely going to result in the reduction of sales/production as compared to where they could have been had they not participated. While overall growth is still expected for a region, cutting emissions is inevitably going to reduce efficiency as well in comparison to if they had not participated.

The Korea Emission Trading Scheme has had its major downfalls in recent years, and with this scheme being relatively new, it is expected to find its bearing. As seen with the EU emission trading system, it is unlikely that the introduction of a carbon market to a well established industry is going to be perfect. It is important to learn from the shortcomings experienced, and strive to create an effective market in which firms can still produce to potential as well as cut emissions.

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